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Acquisition Initiatives in the New Environment: Multi-year Procurement Update

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PREFACE

The Institute for Defense Analyses (IDA) prepared this document for the Office of the Director, Acquisition Program Integration, under a task titled “Acquisition Initiatives in the New Environment: Multi-year Procurement Update.” This document partially fulfills the task objective by providing analyses and displays relevant to current multi-year procurement decisions.

John R. Hiller, Stanley A. Horowitz, and Thomas P. Frazier of IDA were the technical reviewers for this document.

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Outline

- Introduction
- History
- MYP Economics
- Recent Cases
- Summary and Remaining Issues

This annotated briefing picks up on an important theme of research that we have carried out over the years, learning from experience in acquisition. We did two large studies in which we looked at the impact of acquisition program initiatives on the outcomes of the programs in terms of cost and schedule. Our research sponsor, the Office of Acquisition Program Integration (Acquisition Systems Management), requested that we provide an update of information on one initiative, multi-year procurement (MYP).

After a brief introduction, we provide historical perspective on multi-year procurement. MYP history is discussed in more detail in:

- David R. Sutton, "Multi-year Procurement: A Desktop Guide," Naval Postgraduate School, Monterey, CA, June 1997.
- Karen W. Tyson, Neang I. Om, D. Calvin Gogerty, J. Richard Nelson, and Daniel M. Utech, "The Effects of Management Initiatives on the Costs and Schedules of Defense Acquisition Programs, Volume I: Main Report," IDA Paper P-2722, Institute for Defense Analyses, Alexandria, VA, November 1992.

Next, we consider the extent of MYP in recent years. Then, we consider the results of recent cases of MYP. Finally, we summarize results and remaining issues.

Objective

- Provide DoD with up-to-date measures of the costs and schedules of major MYP acquisition programs relative to their initial plans
- Provide case analyses and displays relevant to current MYP program decisions

The objectives of the IDA task are (1) to provide DoD with cost and schedule measures of major MYP acquisition programs relative to their initial plans and (2) to provide case analyses and displays relevant to current MYP program decisions. These objectives require both macro and micro analysis, that is, analysis related to the entire DoD budget and analysis related to the individual program.

What Is Multi-year Procurement?

- MYP: A contracting strategy in which DoD contracts for more than one year of production
- Through funding commitment that allows economic quantity buys, MYP expected to reduce procurement cost

MYP is a contracting strategy in which DoD contracts for more than 1 year of production. The chief mechanism through which MYP works is economic quantity buys—ordering the most economical quantity of parts or components at one time, considering the applicable procurement and inventory costs. Other mechanisms such as greater industry investment and production scheduling have been much touted, but evidence suggests that economic ordering is the principal mechanism through which MYP saves money.

Background

- Currently being used in the C-17 aircraft program
- Has been suggested for other new programs
- DoD wants to consider prior results when deciding which programs should use MYP
- Need up-to-date data and methods for developing MYP policy

In recent years, MYP has fallen into relative disuse. However, a change in the trend occurred in May 1996 when the Air Force awarded an MYP contract for the C-17. The contract for 80 aircraft and engines over 7 years was valued at \$16.2 billion. That represents the largest and longest multi-year contract ever entered into by the United States Government.

Multi-year procurement has been suggested for other new programs. For the F-22, MYP is a major cost-reduction initiative, with planned savings of \$2.4 billion in then-year dollars. Approval of MYP for the F-22 is probably a long way off, given the current instability of the program.

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MYP History

- A Carlucci initiative
- Congressional guidelines
 - not all candidates approved
- Funding requirements also a constraint
 - probably more important than cancellation fee

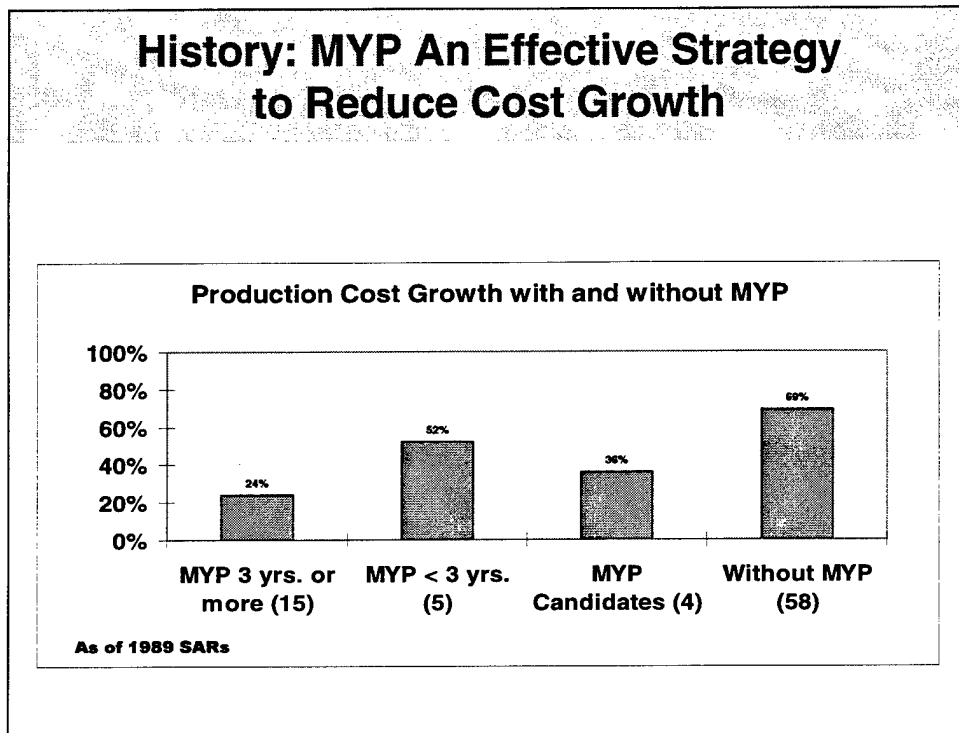
MYP was widely used during the 1960s, then fell into disuse during the 1970s. In 1972, the Navy incurred cancellation charges totaling over \$388 million resulting from problems with shipbuilding contracts. Congress established a \$5 million cancellation ceiling as part of the FY 1973 spending authorization, which effectively eliminated MYP in major DoD acquisitions.

MYP was considered again when Deputy Secretary of Defense Frank Carlucci included it as one of his initiatives in 1981. Shortly thereafter, Congress raised the cancellation ceiling to \$100 million and set guidelines for MYP. The Packard Commission also recommended increased use of MYP.

We obtained summary information on congressional approval rates from Office of the Assistant Secretary of Defense (Comptroller). From FY 1982 to FY 1986, DoD submitted 60 candidates to Congress, and 40 were approved. From FY 1986 to FY 1990, only 32 of 68 candidates were approved.

From this information, it appears that the requirements to fund advance procurement and economic order quantities are probably a greater constraint than the cancellation provisions in the contract. Another constraint is that MYP reduces budgetary flexibility, both for the individual program and across programs. The need to keep funding for MYP programs stable may crowd out funding for non-MYP programs.

History: MYP An Effective Strategy to Reduce Cost Growth

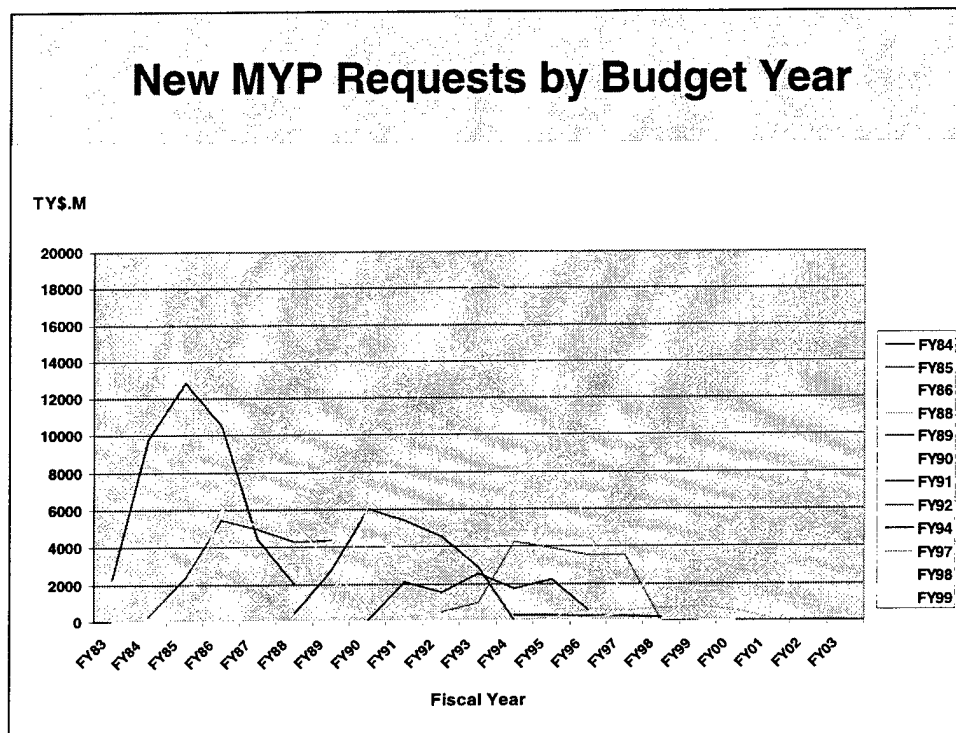


This chart is adapted from IDA Paper P-2722. Here, we compare the production cost growth (over the Milestone II plan, adjusted for inflation and quantity) for MYP and non-MYP programs.

Programs that had 3 years or more of MYP experience at the time of the study experienced production cost growth of 24 percent, on average. Programs without MYP averaged 69-percent growth. Programs that used MYP for less than 3 years had lower cost growth than those without MYP but higher cost growth than mature MYP programs.

We also examined results of MYP candidates, programs that DoD believed met the criteria for MYP but that were not approved by Congress. Cost growth was lower for MYP candidates than for non-MYP programs and programs that used MYP for less than 3 years. However, cost growth for the candidates was higher than for the programs with mature MYP contracts.

The 15 mature MYP programs to which the chart refers are: B-1B, TOW, DSCS III, F-16, DMSP, MLRS, Patriot, Shillelagh, CH-47D, NAVSTAR GPS, SURTASS/T-AGOS, M198 Howitzer, UH-60A/L, DSP, and SSN-688. The five programs with less than 3 years of MYP experience are the AV-8B, AH-64A, TOW2, Maverick D/G, and Improved Hawk. The MYP candidates are F-15A/B, F/A-18, HARM, and Harpoon.



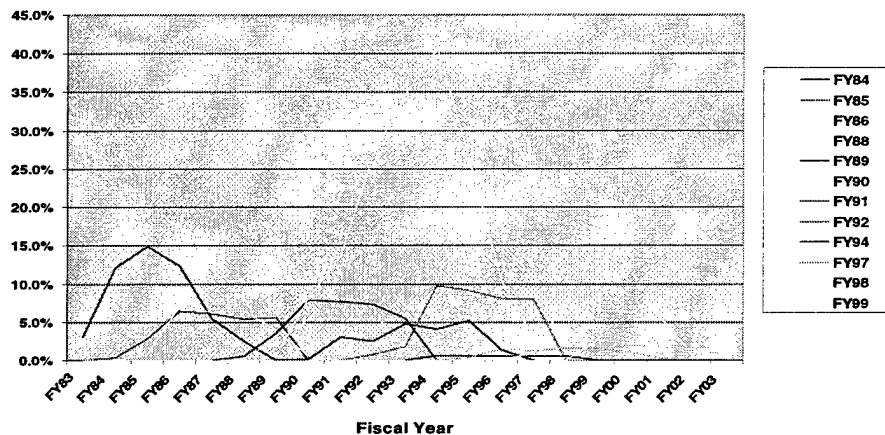
This chart illustrates the volume of MYP requests by budget year. To prepare the chart, we obtained MYP budget submissions from the DoD Comptroller's office. When MYP was relatively widely practiced, exhibits detailing planned expenditures under annual versus MYP contracts were collected into a book. In recent years, exhibits have been submitted by individual programs, but not collected in any way. We obtained exhibits for FY 1984-1999, with the exceptions of 1987 and 1993. There were no MYP requests in FY 1995/96.

The FY 1984 book contained seven MYP requests for major programs. The FY 1990/91 book was also thick, with several MYP requests for very large programs—C-17 (\$13 billion), B-2 (\$26 billion), and F/A-18 and DDG-51 (\$6 billion each). These requests were not approved, although the C-17 and DDG-51 received MYP approval later.

As the chart shows, since FY 1984, except for the large requests in FY 1990/91, the overall trend in MYP requests is downward.

New MYP Program Requests as Percent of Procurement Budget

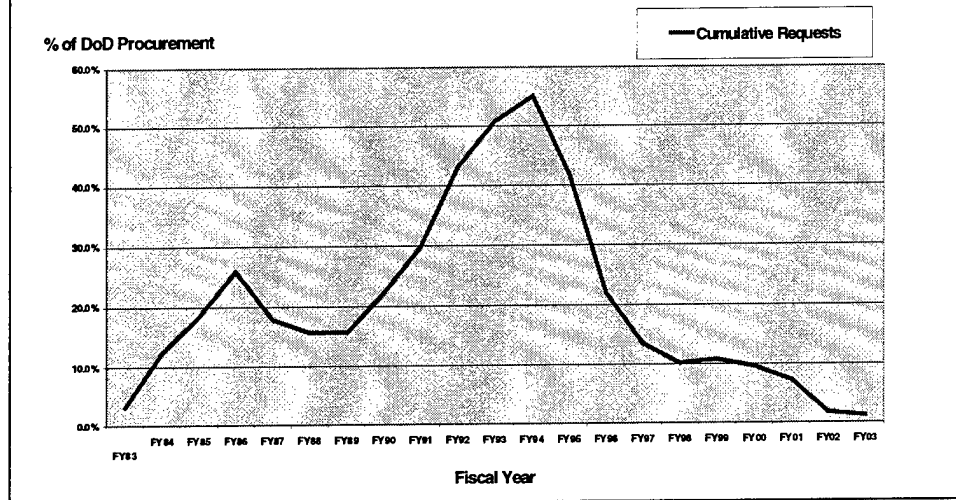
% of DoD Procurement



This chart shows MYP requests as a percentage of the procurement budget. The FY 1984 budget submission called for almost 15 percent of total procurement to be under MYP contracts. With several large requests, the FY 1990 budget called for 40 percent of eventual procurement to be under MYP contracts. By contrast, the FY 1999 budget submission allowed for just over 2 percent of the procurement budget to be under MYP contracts.

The decline in the procurement budget itself accounts for some of the decrease in MYP requests. However, there also have been several years of very low requests relative to the total procurement budget.

MYP Requests as Percent of Procurement Budget



This chart shows MYP requests as a cumulative percentage of the procurement budget. It indicates the percentage of procurement that would have been under MYP if all prior-year requests had been approved.

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- Introduction
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- Recent Cases
- Summary and Remaining Issues

MYP Economics: Annual Contract

- Theory from "The Economics of Multi-year Contracting," Kathleen P. Utgoff and Dick Thaler, CNA Professional Paper 345, March 1982
- Total Cost = $f + B Q$, where
 - f = total fixed cost
 - B = variable cost per unit
 - Q = number of units
- Firm chooses f and B to maximize profits
 - Firm increases fixed costs to save on variable costs
 - Firm will incur fixed costs so long as they lower total costs
- Assume an arbitrary relationship between fixed and unit variable costs, $B=b/f$
 - Thus, $TC = f + b/f Q$
- Expected total costs for 2 years are
 $ETC = f + b/f Q_1 + p b/f Q_2$, where p = probability that Year 2 contract will be executed

In this section, we discuss the economics of MYP. We examine an analytical model of MYP that allows us to think of MYP in a more general way. Consider two annual contracts versus a multi-year contract for 2 years of production. The total cost is always equal to fixed and variable costs.

The firm chooses its total fixed costs and its variable costs per unit to maximize profits. Fixed costs are chosen to save on variable costs and will be incurred so long as they lower total costs.

To make computation easier, choose a simple inverse relationship between fixed and unit variable costs.

People are motivated by expectations, and the expected costs for 2 years of production are equal to the fixed costs, plus the variable costs for the first year's production. In addition, the expected costs include the Year 2 costs, multiplied by the probability that the Year 2 contract will be executed.

MYP Economics: Choosing Fixed Costs Under an Annual Contract

- Choose f to minimize total costs:

$$f^* = \sqrt{b(Q_1 + pQ_2)}$$

- Average costs of the system decline when probability of second year contract increases
- For each p , there is an optimal level of fixed cost f^*
- As p increases (probability of Year 2 contract goes up), the optimal fixed cost f^* goes up
- Thus, stability of funding raises fixed costs but reduces average costs

Under an annual contract, the firm will choose its fixed costs to minimize total costs and thus maximize profits. For each probability of execution of the second year contract, there is an optimal level of fixed costs.

It can be shown that an increase in the probability of the second year contract results in increased fixed and decreased unit variable costs. If the firm believes that a second year contract is probable, it will be willing to raise its fixed costs in order to lower average costs.

What Does Multi-year Procurement Do?

- MYP reduces firm's risks through advance procurement and cancellation clause
 - Reduces risk of uncovered fixed costs
- Firm will choose a higher level of fixed costs with advance procurement than without it
- When funding is close to certain, there is little difference between annual and multi-year contracts
- What MYP does is to increase ρ (probability of continuation)

MYP changes the firm's view of fixed-variable tradeoffs. Through funding of advance procurement and imposition of a cancellation penalty, MYP increases the firm's perceived probability of continuation. When funding is close to certain, there is little difference in the expected cost of annual versus multi-year contracts.

MYP Economics: Multi-year Contracts

- Cancellation fee (C)
 - If second year of program is not funded, and Q_1 rather than Q_1+Q_2 units are produced, then $C = \alpha f$. (α represents proportion of fixed costs refunded.)
- Advance procurement
 - Required to be laid out in detail in budget request
 - Consider time value of money

The distinctive features of multi-year contracts are the cancellation fee and advance funding.

In the Utgoff-Thaler model, the cancellation fee is structured as a refund of some proportion of the fixed costs. This is not necessarily the only way to structure such a fee. Congressional limitations on the size of the cancellation fee have been common in recent MYP implementations.

Advance procurement has been the real deterrent to using MYP in recent years. Under a full-funding policy, up-front costs must be laid out in detail in the budget request, and time value of money must be considered.

Optimal Fixed Costs—MYP Contract

- Expected total costs
 - $E(TC) = f + bQ_1 + pbQ_2 - (1 - p)\alpha f$
- In solving the equation, optimal fixed costs in multi-year contracting can be calculated:

$$f^{**} = \sqrt{b(Q_1 + pQ_2)/(1 - \alpha(1 - p))}$$

Under an MYP contract, then, the expected total costs equal:

- Fixed costs plus
- Variable costs for year 1 production plus
- Variable costs for year 2 production times the probability of executing Year 2
- Less the expected income from the cancellation fee.

Optimal fixed costs under MYP are different from optimal fixed costs under an annual contract, unless the probability of continuation is one.

Annual and Multi-year Contracts: A Comparison

- When continuation is uncertain, firm will choose higher fixed costs and lower variable costs under MYP (vs. annual)
- When $p = 1$, multi-year and annual contracts are very similar
 - Government subsidy term drops out of the multi-year program's expected total cost equation
- Multi-year contracts shift risk to Government, away from firm

When there is uncertainty about continuation, the firm will choose higher fixed costs and lower variable costs under MYP versus annual contracts.

By use of advance procurement and the threat of a cancellation fee, multi-year contracts shift risk to the Government and away from the firm.

Estimating p

- Using 1989 SAR database (latest available):
 - MYP programs procure their planned quantity (or more) 65% of the time
 - MYP programs keep to planned average rate (or faster) 53% of the time
 - Non-MYP programs procure their planned quantity (or more) 60% of the time
 - Non-MYP programs keep to planned average rate (or faster) 42% of the time
- Caveats
 - Old data
 - Includes entire procurement, not just MYP period

We used a database derived from the Selected Acquisition Reports (SARs) (described in IDA Paper P-2722) to develop estimates of the probability of continuation. We used two different factors in calculating this estimate. One is *production quantity growth*, the extent to which a program increased or decreased its planned procurement quantity, regardless of how long it took to procure the units. The second is *stretch*, an indicator of planned versus actual procurement rates, taking both quantity and time into account.

In all cases, MYP programs were more likely to keep to their planned quantity and planned rates, but the differences from non-MYP programs were small.

Some caveats: The database is old. The number of MYP programs is fairly small. The measures we used include the entire procurement, not just the MYP period, and many programs did not use MYP until after several years of production. These measures consider whether programs were stretched at all, not the amount of stretchout. The extent of stretchout in non-MYP programs is considerably greater than that in MYP programs.

Observations from Theoretical Analysis

- Utgoff and Thaler suggest rigorous conditions for MYP
 - Include time value of money—consider upfront costs
 - Use when industry is risk-averse—e.g., underestimates p , underinvests
- DoD uses strict guidelines
- MYP may not increase p as much as we would like
 - Recent picture unclear
- Key reasons for cost growth in early stages of major programs are overestimation of p and building facilities based on overestimates of production rates
- Amount of MYP can be considered by Services and OSD in a macro budget context

Our observations regarding the theoretical analysis include the following:

The Utgoff-Thaler approach has some merit, although it also has limitations. Their conclusion is that MYP should be used very rarely. At the time that the model was developed, DoD did not always take into account the time value of money. Current budget submissions do include this analysis. Utgoff and Thaler argue for use of MYP when industry is risk-averse—in other words, when industry underestimates p and thus underinvests. However, in the early stages of many major programs, industry and Government both plan for a larger buy than actually occurs—they overestimate p and thus allocate too much production capacity.

Based on the data we have, MYP does increase program stability, although not to as great a degree as we had originally thought.

The amount of MYP can be considered by the Services and OSD in a macro budget context. We have shown examples of the extent of MYP in recent budgets. Next, we will show examples of how MYP has affected recent programs.

Outline

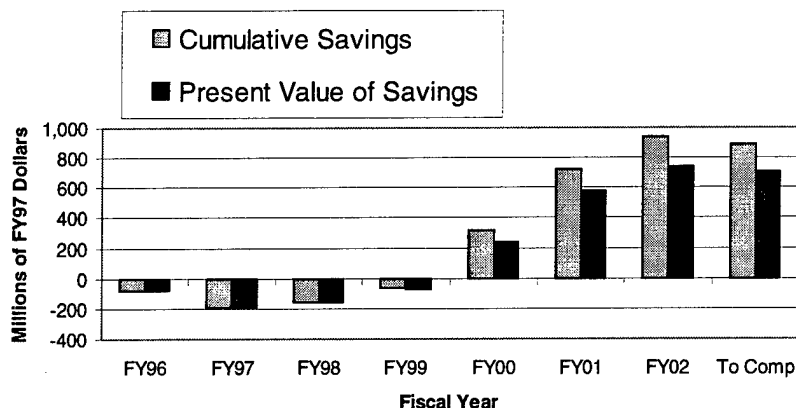
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Recent SAR Programs Using MYP

PROGRAM	MYP Contract	START	END	Contract
C-17	All	FY97	FY03	7 years
Chinook (CH-47)	All	FY86	FY89	4 years
Chinook (CH-47)	All	FY90	FY92	3 years
DDG 51 Destroyer	All	FY98	FY01	4 years
DMSP	Spacecraft	FY89	FY92	4 years
DMSP	OLS Sensors	FY84	FY89	6 years
DSCS	All	FY85	FY88	4 years
FHTV-PLS	All	FY90	FY94	5 years
FMTV	All	FY92	FY96	5 years
Longbow Apache	All	FY97	FY02	5 years
Longbow Apache	Radar frequency interferometer	FY98	FY03	5 years
Longbow Apache	Fire Control Radar (FCR)	FY98	FY03	6 years
M1A2 Abrams Tank	All	FY97	FY02	5 years
Mk-48	All	FY92	FY94	3 years
MLRS	All	FY84	FY88	5 years
MLRS	All	FY89	FY93	5 years
NAVSTAR GPS	All	FY96	FY98	3 years
Patriot	All	FY87	FY91	5 years
Stinger	All	FY87	FY89	3 years
UH-60L BlackHawk	Airframe	FY88	FY91	4 years
UH-60L BlackHawk	Airframe	FY92	FY96	5 year
UH-60L BlackHawk	Engine	FY89	FY93	4 years
UH-60L BlackHawk	Engine	FY94	FY96	3 years
UH-60L BlackHawk	All	FY97	FY01	5 years

This slide is a list of programs actually executing MYP contracts in recent years.

C-17 Planned Savings from Multi-year Procurement

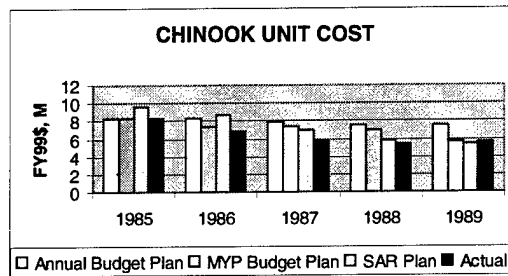
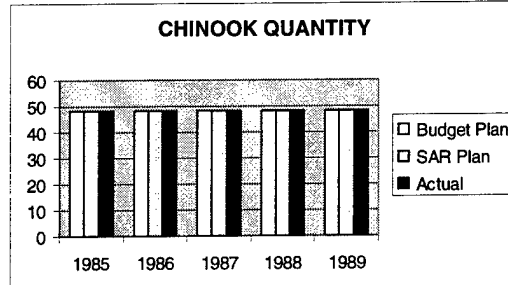


This chart shows the almost \$1 billion MYP savings planned for the C-17 program. The C-17 has been touted as a turnaround success story. (See Col. Randy Davis, LTC Bill Phillips, Lt. Col. Bud Vasquez, "The Phoenix Rises," *Acquisition Review Quarterly*, Vol. 4, No. 4, Fall 1997.) The program started its MYP contract so recently that we cannot see any results from the MYP at this time.

C-17 Experience Will Be Useful Data

- A troubled program that may have turned around
- Performance-based payment during entire MYP performance period
- Cancellation provisions unusually favorable to Government

Chinook Helicopter (CH-47D) (1985-1989)



We looked at recent programs that had completed their execution of MYP, to see how the execution related to the claimed savings.

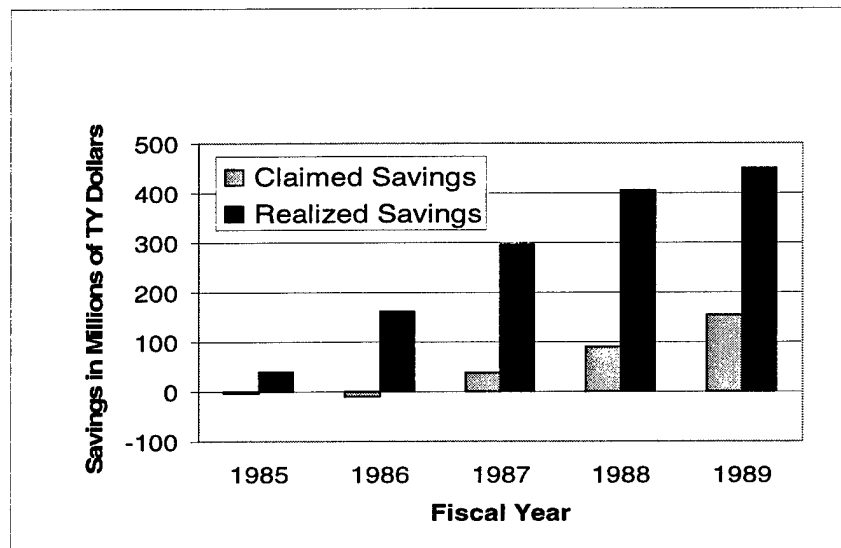
One program with comparable data was the Chinook helicopter, which had two MYP contracts, the first from 1985 to 1989, the second from 1990 to 1992. The final SAR was filed in December 1991 and did not provide final data for the second MYP contract. Therefore, we focused the analysis on the first MYP.

In this and the three following cases, the quantity chart shows planned quantities from the budget plan and the SAR from the year before the MYP and actual quantities from the most recent SAR. The cost chart shows four items: planned unit cost under annual contract, from the Comptroller's submission to Congress; planned unit cost under MYP contract, from the same source; planned unit flyaway or rollaway cost from the pre-MYP SAR; and actual unit flyaway or rollaway cost from the most recent SAR. (The SAR from the year before the MYP usually reflects the planned MYP. Thus, it represents a more rigorous comparison than the annual budget plan, which is an artificial construct.)

The Chinook program had a 5-year MYP from 1985 to 1989.

Quantities were as proposed during the MYP period, but costs were considerably lower than proposed in the middle years of the MYP. In the last year of the MYP, costs were slightly above the SAR plan but still below the MYP budget plan.

Savings from Chinook (CH-47D) MYP Program (FY 1985-FY 1989)



This chart compares the claimed and realized savings in the total program between the annual and MYP budget plans. Realized savings were considerably greater than planned.

Chinook Program Detail Indicates MYP Was the Reason for Cost Savings

- CH-47D achieved technical goals—no relaxation of performance requirements to save money
 - Principal goal was to fix hydraulics, which had created maintenance problems in older models
 - Some increase in lifting ability
 - Extensive upgrade involved stripping to skeleton, almost like building a new one
 - Some rearrangement of plant to optimize for CH-47D (plant previously shared with other programs)

We considered whether there were other reasons why the Chinook came in so far below its cost targets. Among the possible considerations are inflation projections and changes in scope. We interviewed a former Army civilian staff member from the Cost and Economic Analysis Center, who analyzed the program as the MYP was proceeding.

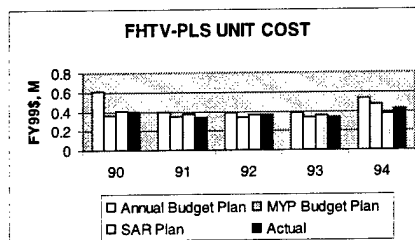
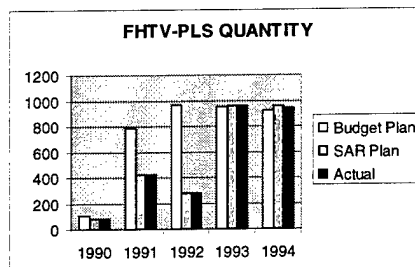
We concluded that the data did not support the inflation hypothesis, and that any changes in scope would have worked in the direction of raising costs, not lowering them. Based on all of this information, we concluded that the principal reason for the low costs was the MYP contract.

Chinook: A Success Story

- MYP allowed advance purchases at good prices
 - Rotor blades, landing gears, helmets
 - Eight-year supply of some items bought by 1984
- Annual program planned at \$1.87 billion, FY85-89
- Actual MYP program cost \$1.42 billion, a 24% saving

MYP allowed the program to buy key components in advance, sometimes as much as an 8-year supply.

FHTV - PLS (1990 - 1994)

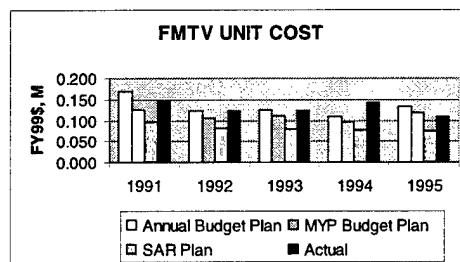
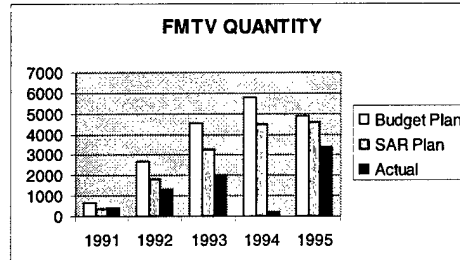


We examined three additional programs, although in less detail than the Chinook. The Family of Heavy Tactical Vehicles-Palletized Load System (FHTV-PLS) consists of sixteen 1/2-ton truck-trailer combinations with some flatracks. The program had a 5-year MYP from 1990 to 1994.

The budget plan proposed higher quantities in the first 3 years of the MYP than the SAR plan. The SAR plan quantities were achieved until 1994, when there was a small cut, from 961 to 945.

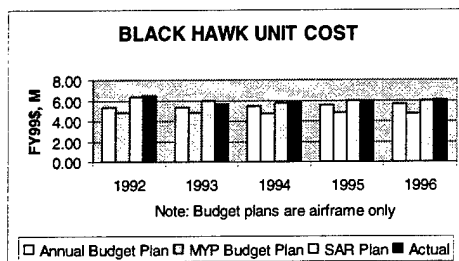
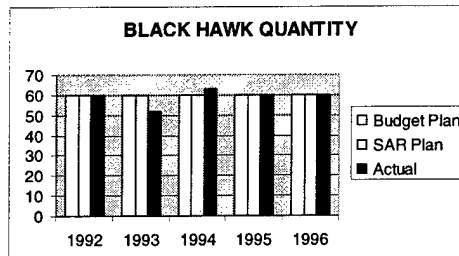
Actual unit costs were higher than the MYP budget plan in the first and third years, and the same or lower in the others. Actual unit costs were lower than the SAR plan in every year but the last, possibly due to the quantity cut.

Family of Medium Tactical Vehicles (1991 - 1995)



The Family of Medium Tactical Vehicles (FMTV) also had a 5-year MYP from 1991 to 1995. Actual quantities were considerably lower than those proposed, both during the MYP period and after. Not surprisingly, unit costs were also higher than those proposed under both the MYP budget plan and the SAR plan.

UH-60L Black Hawk Airframe (1992 - 1996)



The Black Hawk helicopter program used several MYP contracts, among them three airframe contracts (FY 1987-1991, FY 1992-1996, and FY 1997-2001) and two engine contracts (FY 1989-1993 and FY 1994-1996). This slide highlights the results of the 5-year airframe MYP from 1992 to 1996.

The program planned to buy 300 helicopters under the 5-year MYP contract and ended up purchasing a total of 295. The unit cost data for the budget plan are for the airframe only and thus are not comparable to the SAR data. Actual unit costs were higher than the SAR plan in the first MYP year, lower in the second year, and roughly equal in the final 3 years.

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Suggested Guidelines for MYP Use

- Limit to low-risk programs
 - Stable and mature
 - Buyouts at end of program
 - Conclude a competition
- Estimate accurately
 - Time value of money
 - Probability of cancellation
- Perform thorough analysis

Based on both theoretical and empirical analyses, we suggest the following guidelines for use of MYP:

- The up-front cost of MYP is large enough that it is necessary to limit its use to low-risk programs for the Government. Early production units should generally not be procured under MYP contracts. MYP can be a barrier to technology insertion because of its requirement for design stability.
- MYP is particularly appropriate to buyouts at the end of a program, when costs and quantities are well-known.

Conclusions and Recommendations

- MYP has not been widely used—worthy of consideration
- Use of MYP needs to be carefully tailored
 - Suitable programs are those with stable requirement, design, funding, quantity
 - Major new systems need to mature before MYP is appropriate
- Consider MYP options for mature systems in developing optimal production schedules

Given the results of recent programs, we think that MYP is worthy of consideration.

Tailoring of MYP is necessary. In developing optimal production schedules for multiple programs, multi-year contracts should be considered for mature systems.

Additional Issues

- Develop MYP options for future budgets
- Compare outcomes of historical and current MYP and non-MYP programs
- Study recent initiatives and outcomes
 - Commercial components
 - Commercial standards
 - Modeling and simulation
 - Cycle time reduction
 - Activity-based costing
 - Overhead reduction initiatives

Some unresolved issues:

- Information of the kind developed in this study could be used to help consider explicit multi-program MYP options for future budgets. One major unresolved question is the effect of MYP on the stability of non-MYP programs: Does “protecting” the MYP programs make the unprotected programs less stable?
- This study was only able to cover recent MYP programs. It was not able to compare the outcomes of these programs with recent non-MYP programs.
- As a further extension, recent initiatives and outcomes could be studied. Recent innovations such as manufacturing streamlining and acquisition reform have greatly altered acquisition practices. While some of these practices are virtually universal and others are difficult to define, those listed here can be measured. For example, we could measure the use of commercial components in a system by percentage of total dollars or by weight. As these programs accumulate production experience, we could then identify the most effective practices.

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